ADDITIONS TO OUR KNOWLEDGE OF THE FLORA OF THE NARRABEEN STAGE OF THE HAWKESBURY SERIES IN NEW SOUTH WALES.

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(Plate x; eleven Text-figures.)

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During 1933 a systematic examination was undertaken by the Students' Geological Society of the University of Sydney of the fossil flora of portions of the Narrabeen Stage. This Stage is as yet very imperfectly known, notwithstanding its ready accessibility from Sydney. Plant remains and geological data were collected. The Research Committee of the Society consisted of its President, Mr. M. D. Garretty (Chairman), Mr. N. A. Burges, M.Sc., of the botanical staff at the University of Sydney, and Mr. S. W. Carey, B.Sc. The following members participated in the excursions which were held in addition to frequent committee visits: Misses T. Christie, M. Cogle, G. Edgecombe, M. Hayward, B. E. Johnston, V. M. B. May, D. Pearce, N. Repin, N. Robards, E. J. Thompson, N. L. Wilkie; Messrs. F. A. Hanlon, D. J. Lee, R. McGlynn, K. MacKinnon, W. McNiven, K. Mosher, W. Nichols, L. Noakes, J. Pryke, M. L. Wade, J. Yager.

Thanks are due to Dr. A. B. Walkom for much help in connexion with the plant determinations, and also to Professor T. G. B. Osborn, and to Professor L. A. Cotton, for permission to carry out work in the Departments of Botany and Geology, respectively, in the University of Sydney. The geological notes on the Narrabeen Stage are due to Mr. M. D. Garretty.

Geological Summary.

The Triassic Hawkesbury Series of the Sydney District has been divided into three stages, the lowest being the Narrabeen Stage. This is for the most part conformable with the underlying Kamilaroi (Permo-Carboniferous) Coal Measures; it is overlain conformably by the Hawkesbury Sandstone Stage. It was placed by the late Sir T. W. Edgeworth David (1932) as early Triassic (Lower Bunter), and the beds were tentatively regarded as Lower Triassic on botanical grounds by Walkom (1918). Fossil fish and a labyrinthodont lead to the same conclusion. *Unio* indicates the freshwater nature of the sediments. The palaeontological equivalent of the structural continuity of Palaeozoic and Mesozoic exists locally as a gradation in the flora for a few feet (Dun, 1910).

The Stage forms part of the Sydney Geosyncline, and has at Sydney a maximum thickness of about 1,800 feet. It thins out to the south (about Kiama), west (about Lithgow), and north (Gunnedah and Murrurundi), and is truncated to the east at the coastline. Outcrops are in general restricted to the coast and margin of the geosyncline. The sediments near Sydney consist largely of shales and carbonaceous shales, with associated sandstones, tuffs, and hard

fontainebleau sandstone in thin bands. To the north, west, and south, coarser types prevail. On the South Coast near Otford numerous pebbles apparently derived from a Narrabeen conglomerate were found; these in part closely resemble certain Upper Devonian lavas from Yalwal (50–60 miles to the south-south-west). Fragments of large trees and smaller plant remains occur here in a charred state in the tuffs, indicating proximity to points of eruption. These occurrences strengthen the view (David, 1887) that "the probable source of these [cupriferous, see below] particles is the line of volcanic country between Kiama and Mittagong".

A kind of rhythmical alternation of sandstone and shale, on various scales, is not uncommon. The coarser bands frequently have macerated plant remains showing internal signs of far-carriage, while much better preserved specimens occur in the finer laminae. Important and distinctive beds are the Estheria Shales, Cupriferous Tuffs, and the Chocolate Shales. The first (with *E. coghlani*) overlie the Kamilaroi sediments for about 560 feet, below Sydney. Copper-bearing tuffs follow for about 40 feet at Sydney, and also occur higher in the Stage, associated with Chocolate Shales. The latter form a band up to 170 feet thick near Sydney, near the top of the Stage; elsewhere they thin out, and may split into several bands. The Chocolate Shale is considered to be a redistributed tuff, with admixed sediment. The top of the upper Chocolate Shale zone is sometimes taken "for convenience" (Harper, 1915) as the actual top of the Narrabeen Stage, but this is not the case, as it may continue for some distance higher up, as at Sydney. This is important, since most of the plants described were collected not far above the upper limit of the chocolate shale, the principal localities being: Turrimetta Head, Mona Vale, Avalon, and Terrigal. (For a sketch geological map of the area see Culey, 1932.)

Recent work (Culey, 1932) on ripple-marks has shown "the Triassic Narrabeen Lake as a shallow, subsiding, freshwater lake, probably elongated in a N.E.–S.W. direction. Surrounding it one would see areas of low relief from which the sediments are brought down and deposited quietly in the lake, the prevailing calm being interrupted by local disturbances and ejections of tuffs followed again by quiet sedimentation". Washaways are common in sectional form in the cliffs and could be due to sub-aerial erosion, or to local channels in sheet flood erosion. There is abundant evidence of deposition in separate hollows or lakes, and the beds are lenticular (in extent measurable usually as a fraction of a mile). For this reason the Society's original project of zoning the Stage by its flora is seen to be impracticable. Periodical floods seem to have brought sediment and plants for some distance, forming persistent pebble bands and torrential bedding, accompanied by plant remains in a macerated condition. At quieter times plants would come merely from the borders of the individual ponds, and be gently covered by fine sediment. That at times part of the area was dry land is indicated by the occurrence in interformational conglomerates (as at Mona Vale immediately above the Chocolate Shale) of fragments of already solidified shale from elsewhere in the Stage; one such fragment contains a well-preserved *Cladophlebis*.

The work of this paper, geological and botanical, has thus given to the Narrabeen Landscape a greater heterogeneity than was formerly supposed. While occasional events of an all-embracing nature took place, the more peaceful times saw semi-isolated and moisture-zoned plant communities around the separate small lakes, resembling numerous oases in a desert of what was probably dry land (plain of accumulation).

Certain structures were described by Walkom (1925, plate xxxi, figs. 7–9) as "Plantae incertae sedis". Of these, figs. 7 and 8 have been referred to *Araucarites sydneyensis* (q.v.) Occurrences of the structure represented by fig. 9 were found to be quite numerous on certain horizons at Turrimetta Head. They were found not to be referable to a plant or plants, but to be concretions. They are generally dome-shaped, with surface, and the cavity of the overlying shale, striated radially and having a slickensided appearance. Slides show that the concretions have formed in bands of shale with an unusually fine texture; no nucleus was observed as such. Application of the criteria of Richardson (1921) did not lead to decisive classification, but there seems no doubt in this case that the concretions are subsequent rather than contemporaneous. Nodules of an apparently similar type, but without the slickensides, have been collected in the Triassic Wianamatta Stage at Strathfield.

Plant Descriptions.

The following section of the paper contains descriptions of plants found during the course of the work. Some record additional features for species already described, while others are new species. Well-known plants previously recorded from the Narrabeen stage are not discussed, as these have been treated fully by Walkom (1925).

The distribution of the plants is interesting—seldom were many types found on one horizon. Usually the beds contained *Thinnfeldia* and *Phyllotheca* almost to the exclusion of other plants, but here and there beds occur which contain little or no *Thinnfeldia* but are rich in other plants. At Mona Vale an horizon was found in which all the plant remains were referable to *Araucarites*; at Avalon extensive beds were found with *Williamsonia* stems.

Of the following records, the occurrence of fossil wood of the cupressinoid type from the base of the Triassic is of most interest.

Lycopodiales.

Lycostrobus longicaulis, n. sp. Text-fig. 1.

Included in the material collected from Avalon are several specimens of cones. These structures are borne on stems which in some cases are a metre in length. The stems are 2 cm. wide and very long, they show no trace of structure other than a few longitudinal striations, some of which are probably due to folding during preservation. The cone itself is about 8 cm. long by 4 cm. wide and tapers away towards the apex. It resembles fairly closely in general appearance a male cone of *Macrozamia spiralis* even to the suggestion of pointed sporophylls with upturned ends, becoming longer towards the apex of the cone. The sporophylls are spirally arranged. Little can be made of their structure. The specimens are partly casts and partly composed of organic matter. Treatment with hydrofluoric acid followed by nitric acid and potassium chlorate shows the presence of the remains of both thick and thin walled cells and structures which are probably spores; these are much distorted but would be about 20μ in diameter.

Filicales.

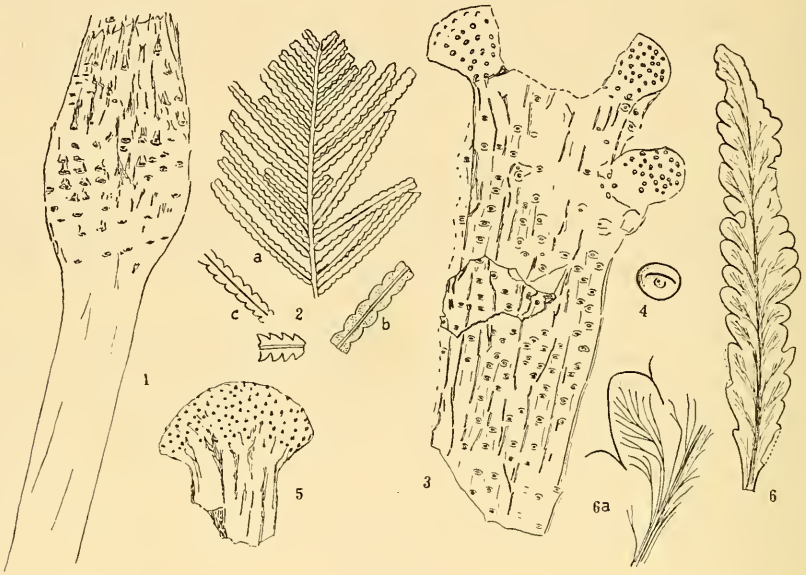
Todites narrabeenensis, n. sp. Text-fig. 2.

Fronds pinnate, probably 30–50 cm. long or more, pinnae linear, pinnatisect, at least 20 cm. long; 3–5 mm. broad in the fertile material, 5–8 mm. in the sterile; the segments in the fertile material orbicular or reduced to crenulations

of the pinna margin; segments of sterile pinnae acute, slightly falcate. Sporangia scattered over the undersurface as in *T. Williamsoni* (Brong.).

T. narrabeenensis differs from *T. Williamsoni* in its much smaller size and its sharp distinction of the sterile from the fertile material.

Material of this species is not plentiful and appears to be concentrated in two or three layers in the grey shales about forty feet above the chocolate layers. Specimens were collected from Turrimetta Head, Mona Vale and Avalon.



Text-fig. 1.—*Lycostrobus longicaulis.* Cone and portion of stalk, × ½. Specimen No. 2003.*

Text-fig. 2.—*Todites narrabeenensis.* *a*, Fertile frond, × ½; *b*, pinna showing sporangia, × ⅔; *c*, sterile pinnae, × ½. Specimen No. 2004.

Text-figs. 3, 4.—*Caulopteris* sp.? 3, Stem with expanded apex, × ½. 4, Leaf scar enlarged, × 2⅔.

Text-fig. 5.—Expanded apex of a stem probably referable to *Caulopteris*, × ½. Specimen No. 2006.

Text-figs. 6, 6*a*.—*Odontopteris dubia.* 6, Frond, × ½. 6*a*, Portion enlarged, × 2. Specimen No. 2007.

Fern Stems.

Caulopteris sp.? Text-figs. 3, 4.

In one horizon at Avalon, large numbers of casts and impressions of stems were found. Some of these are quite large—up to 5 cm. in width and 20 cm. long. The main part of the stem is covered with a series of scars, irregularly placed but tending to form rows with ridges of raised tissue between them. These ridges are usually not regular and are often oblique to the main axis of the stem. The apex is slightly expanded, bearing scars more closely set and less typical in shape. Intermediate types of scars are present at the base of the expanded

* The numbers are those of specimens in the collection of the Geology Department, University of Sydney.

portion. The stem is probably partly or wholly decorticated in the lower region. The scars are elliptical, 2–3 mm. by 1·5 mm. (Text-fig. 4), and show markings which are interpreted as representing an upper sclerenchyma band of tissue and a U-shaped vascular strand.

The specimen illustrated in Text-figure 5 probably also belongs here. Both are referred with doubt to the genus *Caulopteris*.

Pteridosperms?

? Taeniopteris undulata, n. sp. Plate x, fig. 1.

Leaf linear, at least 0·5 metre long, 1·4 cm. wide, midrib very prominent, about 2 mm., lamina very regularly undulate in most specimens, venation taeniopteroid, at right angles to the midrib, veins very delicate, numerous, 30 per cm.

This species resembles in some ways *T. spathulata*, but no basal or apical parts have been seen even in pieces 40 cm. long.

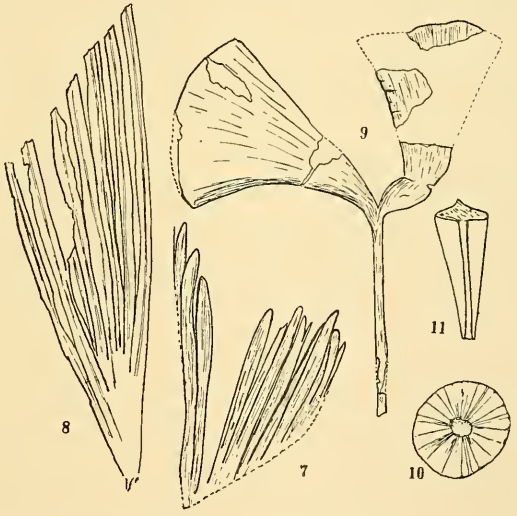
Odontopteris dubia, n. sp. Text-fig. 6, 6*a*.

Leaves simple, linear, lanceolate, 10–12 cm. long, 2 cm. wide, pinnatisected segments rounded, venation odontopteroid. Tapering at the base.

Ginkgoales.

Baiera Simmondsi (Shirley). Text-figs. 7, 8.

Several specimens are probably referable to this Queensland species. There is in one specimen (Text-fig. 8) a suggestion of a midvein in each linear segment. This may be due to folding during preservation, or may indicate that the specimen belongs elsewhere. It is certainly larger than the average *Baiera Simmondsi*.



Text-figs. 7, 8.—*Baiera Simmondsi* (Shirley). 7, Portion of leaf, × ½. 8, Portion of leaf, × ⅓. Specimens No. 2008, 2009.

Text-fig. 9.—*Rhipidopsis narrabeenensis* Walkom. Leaf showing petiole, × ½. Specimen No. 2012.

Text-figs. 10, 11.—*Araucarites sydneyensis* Walkom. 10, Cross section of cone, × ½. 11, Cone scale, × 2. Specimens No. 2010, 2011.

Rhipidopsis narrabeenensis Walkom. Text-fig. 9.

Further material of the above species confirms Walkom's (1925) opinion that it belongs to *Rhipidopsis* rather than *Psygmophyllum*. The specimen figured (Text-fig. 9) possesses a petiole about 5 cm. long—it agrees with that figured by Walkom (1925, fig. 4, Pl. xxx) in having the two segments forming the leaf blade.

Coniferales.

Araucarites sydneyensis Walkom. Text-figs. 10, 11.

The following additions can be made to the description of the above species.

The remains described by Walkom of this species are evidently those of megaspore cones. The specimens illustrated by Walkom (1925, Pl. xxxi, figs. 7, 8) and placed by him in Plantae Incertae Sedis are probably cross sections of a cone referable to this species.

A large series of specimens obtained from Mona Vale shows that the cones were preserved in such a way that all aspects of the cone may be examined. The cones appeared to fracture easily and many were preserved showing cross-sections in which the scales may be seen in situ (cf. Text-fig. 11). Large numbers of detached cone scales were also found.

The cone scales are approximately triangular, about 1 cm. long and about 5 mm. broad, tipped by a short point, with a marked ridge along one side.

Petrified Material.

Previous descriptions of plants from the Narrabeen Stage have been made from casts, impressions or carbonized remains. During the present investigation, material was obtained from Terrigal which, although unpromising in surface view, was well preserved and yielded good sections. Two trips were made to the locality, one by Mr. Noakes, in 1933, who was making a reconnaissance of the area when he found the first piece of material, and a second in 1934 when other members of the society accompanied Mr. Noakes and collected specimens of at least two species.

The remains consisting of petrified stems were embedded in the tuffaceous sandstones which form the cliffs of the Skillion and the headlands immediately to the south. These cliffs in most places are difficult to climb, so the main collecting was carried out among the fallen rock. In one instance material was obtained on the cliff face. Nowhere did the plant remains seem to be at all plentiful, and three to four hours' careful search revealed only six pieces of stem.

When dug from the matrix the specimens are usually surrounded by a layer of coaly material which is more or less prismatized. Frequently they are rounded at the ends, suggesting that disintegration has occurred before preservation. Considerable crushing has occurred, but this has been irregular and areas of undisturbed material are available for examination. The preservation is due to infiltration of calcareous substances, and much of the original carbonaceous material is still present. The cellular structure is well retained and the tracheidal pitting is easily visible. In some specimens the protoxylem elements and the pith cells are recognizable.

Three forms of the material are present, two of these can be assigned to *Cupressinoxylon*; the third is difficult to place, but is here considered as *Cedroxylon*.

CUPRESSINOXYLON NOVAE-VALESIAE, n. sp. Plate x, figs. 2–5.

The specimens are portions of stems or branches, and vary in length, one measuring 70 cm. Owing to compression and also disintegration, they have assumed an oval shape, 5·5 cm. by 2·8 cm., with an ex-centric pith. The pith is well preserved in some pieces but in others has been lost; it measures 3–8 mm. in diameter. The cells increase in size towards the centre, 40μ–60μ in diameter, the walls with circular pits, air spaces between the cells triangular, 8μ. Protoxylem endarch, tending to be split up into wedge-shaped pieces. Tracheids nearest the pith small, 10μ, annular or spiral, metaxylem larger, 30μ, scalariform. Secondary wood showing somewhat irregular annual rings, 0·5–3 mm. wide; spring tracheids large, 30–40μ, slightly irregular, summer tracheids smaller, 20–30μ, and thicker walled, pits in a single row, bordered with circular orifice, rims of sanio apparently poorly developed, usually not distinguishable; checking is evident. Rays simple, 2–8 cells deep, usually 2–4, the cells 20 by 30μ in tangential section and 50–60μ long, tangential pits not clearly shown, 2–4 in the field. Proportion of medullary ray to the wood in tangential section about 1:15. Resin tissue consisting of isolated rows of parenchyma cells fairly evenly distributed, abundant.

In addition to the above, there is material of *Cupressinoxylon* (Pl. x, fig. 6) very similar to *C. novae-valesiae* but differing somewhat. The general features vary little in essential points, the differences being more apparent than real. In cross-section the protoxylem is more irregular than in *C. novae-valesiae* as is the secondary xylem. The only well marked feature is the size of the medullary rays, which are 6–9 cells deep and usually narrower than in *C. novae-valesiae.*

? CEDROXYLON TRIASSICUM, n. sp. Pl. x, figs. 7–9.

Specimens are parts of stem showing fairly well preserved pith and xylem, oval in cross-section, partlv due to crushing and partly to weathering or decay prior to embedding.

The pith is about 8 mm. in diameter, the cells about 40μ in diameter, the walls not very definitely pitted. Protoxylem fairly abundant, in wedge-shaped pieces jutting into the pith. The smaller elements spiral, 15μ in diameter, the larger scalariform, 25μ in diameter. Secondary wood with well-marked annual rings 2–4 mm. apart. Tracheids 30μ in diameter, the summer wood composed of slightly smaller tracheids with thicker walls, bordered pits in a single row, with oblique orifices, rims of sanio very distinct, checking well marked. Rays simple, 3–10 cells deep, usually 4–5 deep, cells 18μ by 25μ in tangential section, 50–60μ long in radial section, walls with 2–6 pits in the field. Wood parenchyma scarce, one or two cells among the summer wood, resinous.

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DESCRIPTION OF PLATE X.

Fig. 1.—? *Taeniopteris undulata*, n. sp. (Specimen No. 2005).

Figs. 2-5.—*Cupressinoxylon novae-valesiae*, n. sp. 2, Transverse section of pith and protoxylem. 3, Secondary wood showing annual rings. 4, Tangential section of the wood. 5, Radial section of the wood showing the bordered pits.

Fig. 6.—*Cupressinoxylon* sp. Primary wood and early secondary wood.

Figs. 7-9.—*Cedroxylon triassicum*, n. sp. 7, Longitudinal section of the protoxylem. 8, Longitudinal section of the secondary wood. 9, Longitudinal section through a medullary ray.